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Kombucha: Is Consumption Safe for Everyone?

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1. Question/Specific Aim

Should we be making recommendations to special populations, such as pregnant women and athletes, regarding the consumption of kombucha, specifically looking at the alcohol, caffeine, and acidity content? If recommendations are to be made, what recommendations could we make to these populations?

2. Hypothesis(es)

Based on our review of the literature, there is little research regarding the effects of kombucha consumption on pregnancy or exercise. We hypothesize kombucha should not be consumed in excess of 300mg/day due to the caffeination and acidity of the beverages associated with kombucha consumption (Van Der Hoeven et al., 2017; Saraf-Bank et al., 2018). Along with this, we hypothesize the alcohol content in kombucha should not dictate consumption during pregnancy due to trace alcohol percentages, less than 1% (Sirisa-ard, et al., 2015). We would hypothesize that the consumption of kombucha should be limited prior to aerobic exercise based on the acidic nature of the beverage, however the low pH could prove beneficial for anaerobic exercise (Caciano et al., 2015).

3. Methods

A questionnaire was written to get a better understanding of kombucha consumption patterns in students at College of Saint Benedict and Saint John's University (CSB/SJU). The questionnaire asked the participants questions about demographic information, and information about dietary habits. There were sections on the questionnaire about exercise patterns, including types of exercise and frequency. There was also a section about family planning, including current and future plans for family. The questionnaire asked about consumption of beverages, some containing a low pH, some containing caffeine and some containing alcohol. After the survey was drafted it was sent to the IRB for approval. Once approved by the IRB it

was sent out to community members at CSB/SJU via email, with a link to forms manager the participants could fill out. Out of 446 individuals that responded to the questionnaire, 91% of the students self-identified as white or Caucasian, and 71% self-identified as female.

4. Preliminary Results

Out of 446 responses, 309 individuals indicated they never drink kombucha. The majority of students indicated they do not drink caffeine prior to exercise. The majority of students indicated they do not consume a pre-workout supplement prior to exercise. Preliminary results indicate that 73% of students thought it was acceptable to consume up to 100mg of caffeine per day while pregnant. The majority of students, 62%, thought it was not acceptable to consume caffeinated beverages while pregnant. However, 69% of the students thought it was acceptable to consume kombucha while pregnant.

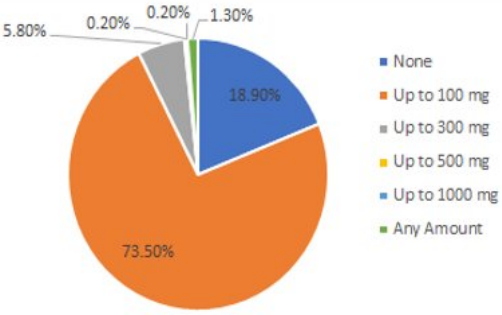

Figure 1. Responses to, "While pregnant, what daily amount of caffeine is acceptable? n=446.

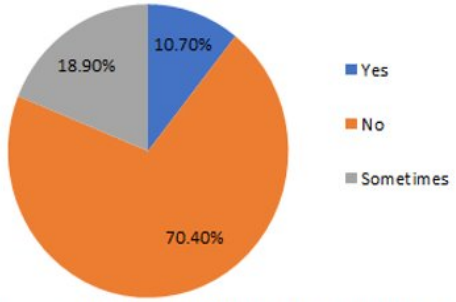

Figure 2. Responses to, "Do you drink caffeinated beverages leading up to physical activity?". n=446.

5. Preliminary Discussion

Based on the results, it is clear that CSB/SJU students do not know the properties of kombucha. This statement is supported by the majority of students saying it was unacceptable to drink caffeinated beverages while pregnant, yet the majority agreed it was acceptable to drink kombucha, a caffeinated beverage. These students may one day (or already are) become special populations, such as athletes or pregnant women. These students should have access to guidelines for said populations in regard to kombucha consumption, of which there are currently none. Future research needs to be conducted to fully examine the effects of kombucha consumption on special populations, such as pregnant women and athletes.

6. Introduction/Background/Relevance/Innovation of Future Research

In recent years, kombucha popularity has increased due to the health benefits associated with the beverage (Martinez et al., 2018). There have been health benefits associated with kombucha through nonhuman trials, however there is still a need for human trials (Kapp & Sumner, 2019). Kombucha components of acidity, caffeine, and alcohol create a need for research for pregnant women and athletes, as little is known of the effects of the components within kombucha.

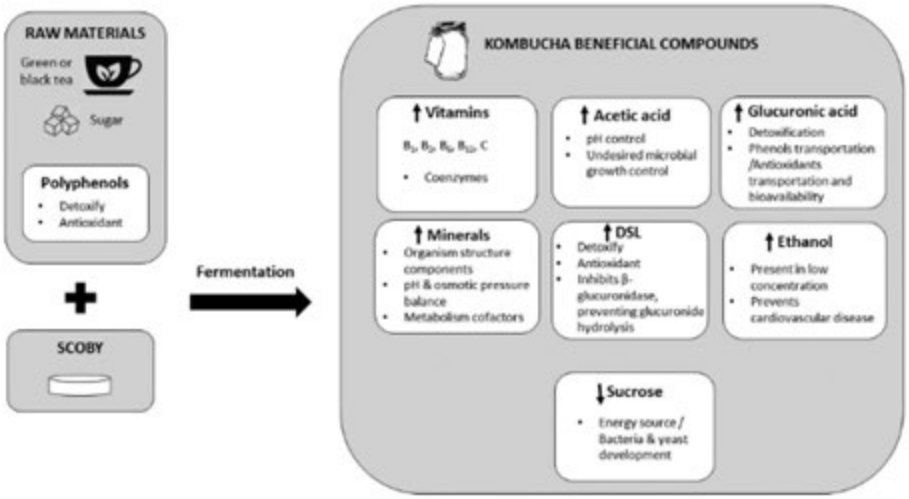

Figure 2. Kombucha beneficial compounds.

Figura 2. Compuestos benéficos de la kombucha.

(Martinez et al., 2018, p. 394)

In pregnant women, high acidity intake through the diet increases risk for gestational diabetes mellitus (GDM) (Saraf-Bank et al., 2018). Kombucha pH decreases as fermentation occurs, typically ending in the range of 3.0-3.9 pH (Sirisa-ard et al., 2015). A low pH indicates high acid content. A highly acidic diet is thought to be responsible for insulin resistance during pregnancy, directly affecting glucose uptake and placing the mother at greater risk for GDM (Saraf-Bank et al., 2018). Glucuronic Acid, found in kombucha, protects the body against high levels of hormones, such as estrogen, which may be beneficial during pregnancy (Martinez et al., 2018).

In athletes there have been shown that there can be negative side effects of a low dietary pH during exercise. The low pH can be linked to an increased risk of bone degradation, and heart disease. It is recommended that athletes do what they can to reduce their individual dietary acidity load, while maintaining nutritional guidelines for athletes (Applegate et al., 2017). There has been some research that has shown that there could be a benefit of having a higher dietary acid load during aerobic exercise, the low pH could be beneficial for lipid breakdown,

beta oxidation (Caciano et al., 2015). Increasing the amount of hydrogen ions in the circulating blood and muscle tissue will decrease the adenosine triphosphate (ATP) production in the muscles leading to a decrease in muscle function. (Powers & Howley, 2018). ATP is the compound the body breaks down to get energy to power many different functions, such as muscle contraction, cellular work, further ATP production, and many more. The human body relies on the body's production of buffers to have an increased amount of hydrogen ions circulating. The body has a small capacity for buffering acids. Hydrogen ions are released as a byproduct of cellular respiration. Even a small change in the pH of the body can lead to harsh side effects on the body, including muscle degradation, decreased ATP production, resulting in a decreased force production (Powers & Howley, 2018).

Caffeine consumption in Polish populations during pregnancy is currently well above the recommended amount of 300mg/day (Blaszczyk-Bebenek et al., 2018; Van Der Hoven et al., 2017). However, after researchers advised the pregnant women about the negative consequences of high caffeine intake during pregnancy, overall caffeine consumption decreased, indicating a lack of knowledge about healthy consumption patterns during pregnancy (Blaszczyk-Bebenek et al., 2018). Among the negative effects of high caffeine consumption (above 300mg/day) during pregnancy is an increased risk of miscarriage (Blaszczyk-Bebenek et al., 2018). Aside from miscarriages, obesity complications for the child may arise due to the mother consuming high caffeine amounts (>300mg/day) during pregnancy (Blaszczyk-Bebenek et al., 2018). Kombucha contains low levels of caffeine (Martinez et al., 2018). A major benefit of kombucha is that it contains antioxidants which remove harmful free radicals from the body (Amarasinghe et al., 2018). When left unchecked, free radicals can lead to calcification within the kidney, disruption of metabolism, and cellular degeneration (Amarasinghe et al., 2018).

Caffeine has been shown to have some benefit to athletes. Showing an increase in athletic performance and strength (Graham, 2012). Caffeine is a stimulant that may be

beneficial to certain athletes. When caffeine is digested in the body it follows three pathways, it helps with fatty acid oxidation, it helps bring calcium into the intercellular fluid, and finally it is an adenosine receptor antagonist (Porrini & Del Bo', 2016). Caffeine would allow for athletes to train harder for longer (Graham, 2912). The increased ability to exercise at a higher level and for a greater duration would allow for the athletes to see more gains and adaptations due to exercise at a faster rate. There is little evidence suggesting a link between caffeine and an increase in strength output (Graham, 2012). For athletes having some caffeine before exercise or a competition can be beneficial. The theory is that caffeine helps with beta oxidation, and will increase the time to fatigue during endurance exercise (Graham, 2001). Adding caffeine to a pre exercise ritual can have some benefits, however the athlete must be careful to look at the restrictions that are placed on sports about specific supplements to make sure that caffeine is allowed by sports. When calcium is brought into muscle cells it works to trigger muscle contractions. The oxidation of fatty acids allows for the breakdown of stored triglycerides, and these fatty acids are able to be used in ATP production. Creating more ATP will allow for an increase in cellular work, the muscles are able to contract at a faster rate and will be able to do work for a longer period of time. The caffeine working as an adenosine receptor, it will allow individuals to stay up.

Alcohol intake during pregnancy is known to have detrimental effects on the developing child. Yet in a recent study, 23% of women reported consuming alcohol during pregnancy (Sbrana et al., 2016). Fetal Alcohol Syndrome (FAS) is a well-known and documented condition within children whose mothers consumed alcohol during pregnancy (Jones & Smith, 1973). Effects of FAS include but are not limited to: prenatal growth deficiency, postnatal growth deficiency, cleft palate, epilepsy, and stillbirth (Jones & Smith, 1973). Aside from FAS, another effect is low birth weight, which increases the risk for infant mortality and inhibited growth (Sbrana et al., 2016). There are no benefits to consuming alcohol during pregnancy.

Combining alcohol and exercise is never good. Research shows alcohol has its own specific digestion pathway, which can lead to impairments and put an athlete in a dangerous situation. Alcohol consumption prior to exercise can cause a decrease in force production during strength and power exercise. Alcohol consumption will decrease the production of amino acids and glycogen in the skeletal muscles (Sayed et al., 2005). The decrease in the production of these two macronutrients will result in a decrease of energy, decreasing the time to fatigue in anaerobic exercises and will decrease the body's ability to repair muscle. The excessive amount of drinking, greater than or equal to (1 g ethanol kg−1 body mass) has been shown to cause an increase in recovery time after exercise (Levitt et al., 2017). This means it will take longer for athletes to recover from exercise after a night of drinking. The breakdown of ethanol in the body takes priority over the digestion of other nutrients. When recovering from exercise it is important to get proteins in your body to help repair muscle damage, when the body is digesting alcohol, it is not getting the proteins into the muscles and therefore not recovering from the damage caused by alcohol as well. It has been shown that college athletes tend to engage in more alcohol consumption, and binge drinking activity (Levitt et al., 2017). There are many different factors that put college aged athletes at risk for an excess alcohol consumption. Throughout most sport culture there is an expectation of alcohol consumption in celebration or defeat. It is important to take this information into account when making recommendations for kombucha consumption for athletes, and especially college aged athletes.

There is a gap in the research for specific populations regarding consumption of kombucha, specifically looking at the components of alcohol, caffeine, and the acidic content. After a review of the literature and with our backgrounds in Integrative Science, we intend to produce guidelines for these groups, pregnant women and athletes, in regard to safe kombucha consumption.

7. Approach

It is unethical to conduct a study purposely requiring pregnant women to consume beverages containing questionable nutritional components such as caffeine, acidic elements, and alcohol (Sbrana et al., 2016; Blaszczyk-Bebenek et al., 2018; Saraf-Bank et al., 2018). Therefore, the experiment process will be conducted through a questionnaire format, as other past studies have done when dealing with a pregnant population (Blaszczyk-Bebenek et al., 2018; Saraf-Bank et al., 2018; Sbrana et al., 2016; Van Der Hoven et al., 2017). The questionnaire will be standardized based on demographics, health, fitness and lifestyle patterns. Questions will be based on general demographics, consumption patterns, physical activity levels, and family history. Upon learning of pregnancy by visit to a participating CentraCare health network practitioner found in Central Minnesota, United States, pregnant women will be asked to participate in the study. When informed consent is granted, the women will submit to routine examinations for child development progress, such as organ development, body length, and size. These examinations will occur once a month for the first two trimesters, and then biweekly for the third trimester to record fetal development. An ultrasound will be used to determine fetal development. A practitioner will determine whether fetal development at each stage is exceeding, normal, or below expected levels. At each examination, the mother will be evaluated for GDM using an Oral Glucose Tolerance Test. Mother's blood pH and blood glucose will also be taken to help determine the overall health of the mother.

At each examination, the women will report consumption levels of kombucha, tea, alcoholic beverages, coffee, energy drinks, and other caffeinated beverages. Upon birth, examination will commence on the baby, indicating length discrepancies, low birth weight, high blood pressure, etc. Following birth, once a year for 8 years, the mothers will be asked to complete a questionnaire related to their child's development: physically, cognitively, mentally, and socially. Additionally, the mother's will bring the children to their corresponding CentraCare Clinic and the children will perform ECSA, WISC-R and WRAT-R tests. The ECSA test will be

administered at age 4 to determine social development, as ages 1-4 have been identified as a major time of social growth (Guerra et al., 2012). The WISC-R and WRAT-R tests will be administered once each year starting at age 5 and will go through age 8 to determine cognitive and mental development (Westat Inc., 1989).

Mothers that did not consume high levels of caffeine/alcohol/acidic beverages (300mg/1 drink of 5% alcohol/300mg>) prior to childbirth will be considered the control group. Mothers reporting higher levels of said beverages prior to childbirth will be the experimental group. If mothers report high in one nutritional element but not others, they will be considered part of the experimental group. Each element will be analyzed separately based on respective amounts consumed for each caffeine, alcohol, and acidity. Results for each respective group will then be compared to childbirth outcomes and will be analyzed using a two tailed T-test with a significance level of 0.05. If results are significant for one nutritional element but not the other two, then guidelines should be adjusted based on that nutritional element. The findings will be compared to past research regarding safe consumption levels during pregnancy and will be refined to fit the experimental results.

The information provided will be given by the mothers and may not be accurate, a clear limitation of the study. Expected results are that women reporting higher than the set parameters for each tested nutritional component will see adverse effects in their child's development and overall health. Due to the length of the study, it is expected that some mothers begin but do not complete the questionnaires through the duration of the survey. Those that do not participate to the end of the experiment will be discarded. To encourage participation until experimental completion, a $100 Visa gift card will be given away each year post childbirth. Because the experiment is questionnaire based, there may be differences in interpretation of the questions among participants. Another limitation is that participants may choose to not answer all of the questions. Development progress will be determined by varying practitioners and therefore there will be variance among what is considered normal fetal development.

The hypothesis is that mothers that exceed allowed values within each respective nutritional category will see adverse effects within their children before and after birth (Jones & Smith, 1973; Blaszczyk-Bebenek et al., 2018; Van Der Hoven et al., 2017). Kombucha does not have high levels of caffeine or alcohol, so their effect would be considered negligible (Amarasinghe et al., 2018). Therefore, it is hypothesized that recommendations for kombucha consumption will be directed toward the acidic results found in this study.

A proposed study to look at the effects of kombucha on athletic performance, would be set up as random control cross over trial. The athletes would be randomly assigned into control or an experimental group. There would be a set exercise protocols to workout anaerobic and aerobic capacities. The participants would be instructed to follow an exercise program, without drinking kombucha, and then after two weeks of consuming four ounces of kombucha a day. By testing the Vo2 max or the individuals we would be able to see the effects on aerobic capacity. Blood lactate, blood glucose and rate of perceived exertion (RPE). Using a T test to compare the trials with kombucha consumption and without consumption, I will be able to further my understanding of the effects of kombucha consumption on athletic performance. Various components of kombucha will have effects on different parts of adaptations due to exercise. The caffeine component of kombucha will have an impact on fatty acid oxidation, which will allow for an increased aerobic exercise performance, which will be shown with an increase of VO2 peak. The movement of calcium into the muscles could show an increase in anaerobic performance which will be shown by an increase in time to lactate threshold and an increased muscle performance.

Each participant will be asked to complete part of the experiment throughout a long period of time. In order to make sure that possible results of kombucha are seen, this study will have to last for a few months. The participants will be asked to complete one part of the study, and then come back and complete it a few weeks later. Allowing for two weeks between trials with kombucha consumption or consumption will allow for adaptations in muscles to take place.

These adaptations will allow the researchers to see if there are improvements in athletic performance with kombucha consumption. The participants will come into the lab and upon their first time in the lab they will be placed into groups, for their first test, and be made familiar with the testing equipment and procedures. Individuals that are in a group without kombucha consumption would be able to take baseline measurements within a few days of the initial time in the lab. When the participants are asked to consume kombucha, they will be asked to consume four ounces, standard serving size, per day and resume normal life.

For anaerobic exercise the participants will be asked to complete 3 sets of 8 repetitions of both a horizontal dumbbell bench press, at a weight of their choosing about 70% of their one repetition maximum weight, they will be asked to follow the similar procedure with a deadlift. During each of these exercises the participants will be hooked up to a metabolic cart, and a VO2 peak measurement will be obtained throughout the exercise. Blood lactate, blood glucose and RPE will be measured at the conclusion of each set. For aerobic exercise protocol the participants will run a standard VO2 treadmill test. They will be hooked up to a metabolic cart to measure VO2 peak. The grade of the treadmill will increase each three minutes, following standard VO2 max protocol. The same blood values and RPE will be measured every three minutes.

The hypothesis is there will not be a statistically significant benefit to kombucha consumption and athletic performance. Kombucha has numerous components to it, which is different depending on the brand and the location of brewing. Looking specifically at caffeine, acidity and alcohol content. There are trace amounts of alcohol, less than half a percent (.5%) we would not expect to see much of an impact, if any, in regards to the alcohol levels in kombucha. There is a small amount of caffeine in kombucha, I do not believe it will have an impact on exercise. The acidity of kombucha is the component which could have an impact. The body has a good way of buffering the blood, however the body can only buffer so much. During exercise the pH of the blood and body decreases as a result of the free hydrogen ions

that are floating in the bloodstream. Starting off with an already decreased pH environment could have an impact on duration of exercise and athletic performance.

8. Conclusion

With little research available for consumption of kombucha during pregnancy, specifically regarding the alcoholic, acidic, and caffeine components, the results will be relatively new and can be used as a guide for kombucha consumption and can help build upon known effects of high alcohol, caffeine, and acidic intake during pregnancy (Blaszczyk-Bebenek et al., 2018; Saraf-Bank et al., 2018; Sbrana et al., 2016; Van Der Hoeven et al., 2017). The results of this research will help inform and guide women in regards to kombucha, and other drinks containing alcohol, caffeine, and high acidity, consumption during pregnancy. The limited research also limits the recommendation that could be made for the consumption of kombucha for athletes, there are some characteristics that can be beneficial to athletes but it is not known if the risks outweigh the rewards.

There are clear limitations to the proposed study involving pregnant women: the mothers will report the data, including levels of consumption of alcohol (including alcohol percentage), caffeine, and acidic intake, family history, exercise, among others. Another limitation is the experiment could be biased based on doctor experience and what each doctor considers normal fetal development. A third limitation is indicating which components led to adverse development effects in the children from mothers who reported high levels of alcohol, caffeine, and acidity; or if other factors were responsible, such as smoking. Lastly, the study will be conducted for an extensive period of time and participation may diminish as the time frame advances. There are limitations that would be presented during a study conducted on athletes. There is limited research that has been done on testing the effects of kombucha and seeing what long-term effects that could come from constant kombucha consumption.

There are limitations when studying athletes, everyone is at a different fitness level, which could skew the data. I will attempt to overcome this by comparing the results of the individuals to themselves and seeing if there is a general trend. There are many components in kombucha that are not being addressed in this study or this paper. Those components are not controlled and will be present or not depending on the location of brewing and the type of SCOBY. The factors that go into the process of making kombucha are different, meaning that there could be some micronutrients that are present in one batch made by one brewer that can be completely different from a different batch or a different brewer. The short time period of the study, of only lasting a few weeks may not show the best results, but it will give an idea to see if there is a correlation present, allowing for more in-depth research.

Future research should conduct an experiment where the entire diet is controlled except for the drink. All smokers or those identified having an unhealthy lifestyle (no physical activity) should be eliminated from the study. The results will then be more accurate as to the cause of resulting effects and could refine the guidelines produced by this experiment. By looking at the effects of a controlled diet, the researchers would be able to see if specific components of kombucha would lead to the desired outcomes. The researchers would be able to break down the components of kombucha, to look at the alcohol content, the amount of caffeine and the acidity of the beverage. By doing this the researchers would have a better idea of what effects those specific elements have on special populations.

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